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Annual Reports :: Year 6 :: University of Colorado, Boulder

Project Report: Origin of multicellularity and complex land-based ecosystem

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Project Progress

During the 2003–2004 year significant progress has been made characterizing fungal symbionts in early land plants. Nearly all land plants have a mutualistic fungal symbiosis: the plant host gains access to essential mineral nutrients through the fungus and the fungal symbiont acquires fixed carbon from the plant. However, the evolution of the mycorrhizal association over the nearly 500 million–year course of land plant history has rarely been studied. We are characterizing the fungal symbionts in early lineages of land plants that have a life cycle where one phase is above ground and photosynthetic and another phase is completely underground. This subterranean phase in these poorly understood plants is completely dependent on a set of fungal symbionts to provide a source of organic carbon. Based on our analysis, this type of plant life cycle involving a subterranean phase (that may last up to 15 years) may be relatively ancient among land plants. Recent research suggests organisms that survive catastrophic impacts typically have an underground component such as a spore, or seed. Thus, a long-lived subterranean life cycle phase in early land plant lineages may have increased ability to avoid extinction following an asteroid impact. For example, these lineages have survived the P–T, and K–T impacts.

Although the presence of fungal symbionts in early plant lineages has been known for many years, this is the first study to determine the fungal symbionts in early land plant lineages using DNA sequence identity. To date, the fungal symbionts throughout the life cycle in early land plant lineages (*Psilotales* and *Ophioglossales*) have been identified as glomalean fungi using DNA sequence data. A collecting trip to Ecuador in May 2004 gathered samples of lycopods (another early plant lineage) that are currently being studied. In addition to studying the fungal symbionts within early land plants, we have started to identify the fungal symbionts in neighboring plants within the community to place our data in a larger ecological and evolutionary framework. Based on DNA sequence data, subterranean phases of the life cycle in these early land plant lineages obtain fixed carbon through an extensive fungal network connected to photosynthetic neighboring plants. The fungi that form symbiotic associations with the underground phases of the life cycle in early land plant lineages represent a specific sub-sample of the total fungal diversity present in

the above ground phase and the photosynthetic neighboring plants. By elucidating the evolutionary patterns of the fungal symbionts throughout the life cycle of these early land plant lineages, we have begun to shed light on the coevolution of fungi and land plants.

Highlights

- Based on DNA sequence identity, we have identified the symbiotic fungi associated with early land plants throughout their life cycle. These symbiotic fungi represent an ancient lineage of fungi that are known to form essential symbiotic fungal associations with most extant plants. The coevolution of this ancient symbiotic fungal association throughout land plants potentially facilitated the evolution of the current complexity of terrestrial life.
- We have compared the fungal symbionts in the subterranean life cycle phases of early land plants to the fungal symbionts present in neighboring photosynthetic plants. These data suggest that the underground life cycle phases in these early plant lineages obtain carbon through a fungal network. Recent research suggests organisms that survive catastrophic impacts typically have an underground component such as a spore, or seed. Thus, a long-lived subterranean life cycle phase in early land plant lineages may have increased ability to avoid extinction following an asteroid impact by obtaining carbon through a fungal network.

Roadmap Objectives

- **Objective No. 4.2:** Foundations of complex life
- **Objective No. 5.1:** Environment-dependent, molecular evolution in microorganisms
- **Objective No. 5.2:** Co-evolution of microbial communities
- **Objective No. 6.1:** Environmental changes and the cycling of elements by the biota, communities, and ecosystems